SEASONAL PLANKTONIC BIOLUMINESCENCE IN THE SOUTHERN CALIFORNIA BIGHT

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LONG TERM GOALS

Very little is known about the seasonality and sources of planktonic bioluminescence in coastal waters along most continents as are the underlying environmental conditions basic to understanding and prediction. There is little doubt that to adequately understand and predict planktonic bioluminescence in any ocean, measurements must be conducted on a continual basis to account for the interannual variability. The long term goal of this project was to understand the interannual dynamics of coastal and open ocean bioluminescence with particular reference to the seasonality of planktonic bioluminescence.

OBJECTIVES

The objectives of this project include (1) regional variation of planktonic bioluminescence - the main question we are attempting to answer is just how much variation does planktonic bioluminescence exhibit in the Bight along the coast (San Diego Bay (SDB) and offshore at San Clemente Island (SCI). Do they track one another or are there real differences? (2) Are there robust environmental predictors of bioluminescence? Short term correlations of temperature, chlorophyll fluorescence, and beam attenuation have been observed in this and other studies. The critical question is whether these correlations break down on a seasonal basis? (3) Is there a seasonality or succession to the species composition of bioluminescent plankton along the coast and at sea? We ask if the trends we have observed for the last 4 years represent the true species succession for the Southern California Bight, an area which is known for a "dampened" seasonality. This work was supported by ONR Biological Oceanography.

APPROACH

The approach to this study was multi-tasked. In this study, bioluminescence was measured at two fixed stations on a daily long term basis: one in SDB for 4 years (1992-1996) and the other for 2.5 years (1993-1996) at SCI located 100 km off the California coast. These two stations used MOORDEX bathyphotometers for measuring bioluminescence. The MOORDEX bathyphotometers developed at UCSB were critical to making the longest continuous study of bioluminescence possible since they are the

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first moored system to survive for any significant period of time. Additional surface and at-depth bioluminescence data were collected on a monthly and quarterly basis at both fixed stations and from a research vessel to provide a link between coastal and offshore waters. Additional factors such as seawater temperature, salinity, beam attenuation, and chlorophyll fluorescence were also measured. Plankton collections were made weekly in SDB and monthly at SCI. Upwelling indices (North Pacific Ocean wind-driven transports) were obtained from 1992 through 1996. Monthly rainfall data were acquired from the National Weather Service in San Diego. Nutrient and chlorophyll *a* were accessed from archived CALCOFI data in the Bight and were averaged along CALCOFI lines 90 and 93 which run west from San Diego to the north and south of SCI (1). These data were used to calculate correlations with bioluminescence, rainfall, and upwelling at SDB. This study provides unique correlated coastal and open ocean data collected on a long term basis.

WORK COMPLETED

Four years of continuous bioluminescence data have been collected at SDB and 2 1/2 years of continuous bioluminescence data have been collected at SCI. Quarterly bathyphotometer station data from 1994 - 1997 have been collected and analyzed with respect to the relationship of integrated water column chlorophyll with integrated water column bioluminescence. Plankton samples have been examined for species composition and enumerated from various locations within the bight, particularly coastal areas as far north as Oceanside, CA. Several manuscripts were prepared for publication this year. The paper entitled "Long Term Dinoflagellate Bioluminescence, Chlorophyll, and Their Environmental Correlates in Southern California Coastal Waters" by Lapota, Duckworth, Groves, Rosen, Rosenberger, and Case was completed and submitted for publication to *Marine Ecology Progress Series* (2). It was accepted pending revision. A second paper entitled "Seasonal Planktonic Bioluminescence in the Southern California Bight" was accepted and is in press, to be published in "The Responses of Marine Organisms to Their Environments", *Proceedings of the 30th European Marine Biology Symposium, 1997* (3). A third paper entitled "Threshold Level Determination to Visually Detect Swimmers and a Swimmer Delivery Vehicle (SDV) at Night Using Bioluminescence (U)" was prepared, submitted, and accepted for publication in the *U.S. Navy Journal of Underwater Acoustics*, July 1997 (4). A fourth paper is in preparation entitled "Seasonal Changes of Bioluminescence in Photosynthetic and Heterotrophic Dinoflagellates at San Clemente Island."

RESULTS

Our work shows that there is a seasonality of bioluminescence in the southern California Bight coastal waters with an obvious maximum and minimum signal in the spring and fall in SDB. A winter maximum and summer minimum in bioluminescence was measured at SCI. In SDB and at SCI, we observed a through the year change in dinoflagellate species composition and their contribution to bioluminescence. Chlorophyll *a* also showed similar seasonal trends with respect to location, however, measured monthly means of bioluminescence did not correlate with chlorophyll *a* either at SDB or SCI. Mean monthly surface seawater temperature did not correlate with mean

monthly bioluminescence at either site; that is, maximum bioluminescence did not always correlate with either maximum or minimum seawater temperatures, although minimum bioluminescence was measured during the coolest water temperatures (winter) at SDB in 1994 and 1996. The largest peak in bioluminescence measured at SCI (winter 1995) was associated with the coolest seawater temperatures (14 -15 °C) during winter.

Total rainfall strongly correlated with measured bioluminescence at SDB. Years with the greatest rainfall (1993, 1995) affected the total bioluminescence which implies that processes associated with rainfall, such as storm water runoff may be stimulating dinoflagellates and algae production in coastal waters. Our bathyphotometer stations showed that bioluminescence and chlorophyll fluorescence correlated during the summer months when the water column stabilized with a shallow thermocline. These correlations broke down with water column mixing during the fall and winter months but reestablished with the development of the thermocline during the summer months.

IMPACT

These results impact models predicting bioluminescence from global ocean primary production and ocean color since these are based on the assumption that much of the oceanic bioluminescence is derived from photosynthetic bioluminescent dinoflagellates. It is clear from this study that the heterotrophic Protoperidinium bioluminescent dinoflagellates dominate surface water bioluminescence in the world's oceans for a significant portion of the year.

TRANSITIONS

Technology demonstration of moored bathyphotometers at sea for long term bioluminescence data collection has been successful. Data will be used in models trying to predict bioluminescence seasonality in coastal areas. Long term data sets may be incorporated into applied models for swimmer detection by bioluminescence.

RELATED PROJECTS

This project is directly related to the University of California, Santa Barbara, Department of Ecology, Evolution and Marine Biology Ph.D program. The MOORDEX bathyphotometers were designed, built by Dr. James Case at the Marine Science Institute, UCSB. MOORDEX 3 is being maintained and operated by Dr. Mike Latz at SIO.

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